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Accessing, integrating and inhibiting word meaning in poor comprehenders

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Running head: Accessing, integrating and inhibiting word meaning

Abstract

This study examined three processes crucial to reading comprehension (*semantic access, integration* and *inhibition*) to identify causes of comprehension impairment. Poor comprehenders were compared to chronological-age (CA) controls and vocabulary-age (VA) controls. When listening to homonym primes ("bank") versus unrelated primes, controls were faster to name pictures related to dominant (money) and subordinate (river) meanings at 250ms ISI but only showed dominant priming at 1000ms ISI whereas poor comprehenders only showed dominant priming. When listening to subordinately-biased sentences ending in homonyms ("John fished from the bank") versus control sentences, all groups showed priming when naming subordinate (appropriate) pictures at 250ms ISI: VA controls and poor comprehenders also showed priming when naming dominant (inappropriate) pictures. At 1000ms ISI, controls showed appropriate priming whereas poor comprehenders only showed inappropriate priming. These findings suggest that poor comprehenders have difficulties accessing subordinate word meanings which can manifest as a failure to inhibit irrelevant information.

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In order to succeed in education, it is vital to have proficient reading and listening skills. Hence it is crucial to understand the causes of comprehension failure in order to identify children with comprehension difficulties and put interventions in place. Children who have intact reading accuracy and fluency but impairments in the comprehension of written and spoken language (known as 'poor comprehenders') have been the subject of much research yet they are seldom identified within school systems (Cain & Oakhill, 2006; Nation, Cocksey, Taylor & Bishop, 2010). Since language comprehension is a multifaceted process that involves many of the skills that are fundamental to human cognition (Kintsch, 1988, 1998) comprehension can fail for a variety of reasons and it is not yet clear what leads children to develop a 'poor comprehender profile'.

In order to achieve a coherent understanding of text or discourse, it is necessary to recognise individual words, retrieve their meanings, integrate these meanings with surrounding context and inhibit irrelevant information (Perfetti, 2007). These processes become particularly important when we comprehend ambiguous words that can take on different meanings in different contexts. For example, we can light a *match*, go to a football *match*, and meet our *match*. *Match* is a homonym; a word that has a single spelling and pronunciation but multiple meanings. Homonyms are highly frequent in the English language (Rodd, Gaskell & Marslen-Wilson, 2004) and pose a challenge for the comprehender because a single meaning has to be activated and selected on the basis of lexical or contextual factors while other unrelated meanings are inhibited. Studying the time-course of homonym resolution can thus provide insights into the semantic processes that are crucial for comprehension. Using ambiguity resolution as a framework, this study investigates semantic access, integration and inhibition in typically developing (TD) children and examines how these processes can breakdown to cause the poor comprehender profile.

The semantic priming paradigm (McNamara, 2005; Neely, 1991; Swinney, 1979; Taft, 1991) has been used to investigate processing of ambiguous words. 'Semantic priming' refers to the fact that target stimuli (words/pictures) are responded to faster and more accurately if they are preceded by a prime word or target to which they are semantically related. This effect provides an index of the semantic information that has been retrieved on encountering the prime. By varying the inter-stimulus interval (ISI) between prime and target it is possible to investigate priming at different time-points after encountering a homonym and hence how access to homonym meanings changes over the time course of processing.

Semantic priming studies suggest that the multiple meanings of words are accessed immediately after presentation (Barnes et al., 2004; Duffy, Kambe & Rayner, 2001; Henderson, Clarke & Snowling, 2011; Simpson & Burgess, 1985; Simpson & Foster, 1986; Swinney, 1979; Gorfein, 2001). Priming occurs when homonyms are presented as words in isolation (bank – money/river) or as final words in sentence primes (John fished from the bank – money/river) and when the inter-stimulus interval (ISI) from the offset of the prime to the onset of the target is short. Later in processing (when the ISI is longer), one meaning is selected based on lexical factors such as meaning frequency and/or contextual factors. When sentence context is available, meaning frequency interacts with context (Duffy et al., 2001; MacDonald, Pearlmutter, & Seidenberg, 1994; Tabossi & Sbisa, 2001): if a sentence prime is biased towards a subordinate meaning (John fished from the bank) then priming for both context appropriate (river) and inappropriate (money) targets is likely to emerge at short ISIs followed by a maintenance of priming for the context appropriate (subordinate) meaning at long ISIs. However, if a sentence prime is strongly biased towards the dominant meaning (John stole from the bank), priming for inappropriate subordinate targets may not be observed at any ISI.

The extant research suggests that poor comprehenders have difficulties in many tasks that require access to word meaning. Efficient access to word meaning requires fluency of retrieval in addition to breadth and depth of vocabulary knowledge (Tannenbaum, Torgensen & Wagner, 2006). Poor comprehenders are slower and less accurate at naming pictures with low frequency names, but show similar effects of word length on picture naming (Nation, Marshall, & Snowling, 2001). They have been reported to show reduced semantic priming for categorically-related words that are not highly associated (*bed* – *desk*) when compared with decoding-matched controls (Nation & Snowling, 1999) and to have difficulty making synonym judgements for word pairs low in imageability (*fast – quick*) (Nation & Snowling, 1998a). According to Perfetti's (2007) lexical quality hypothesis, the ability to comprehend a text is strongly related to the variability in the quality of the word representations that are encountered. High lexical quality is characterised by "well-specified and partly redundant representations of form (orthography and phonology) and flexible representations of meaning, allowing for rapid and reliable meaning retrieval" (p. 357). Within this view, although poor comprehenders have adequate phonological and orthographic representations of words, low-quality representations (or limited access to them) leads to inadequate comprehension.

The precise nature of the semantic deficit in poor comprehenders and how it interacts with higher-level comprehension processes is unclear. One view is that knowledge of individual words in a text or discourse is all-or-none and when meanings are not available this will impede reading comprehension (Anderson & Freebody, 1981). In contrast, Nation and Snowling (1998a) suggest that the relationship between reading comprehension and semantic skills might be best explained by the speed or efficiency of semantic access, arguing "...if semantic access is slow or effortful then less capacity will be available for comprehension" (p. 98). This is evidenced by poor comprehenders being slower than decoding-matched controls at reading low-frequency and exception words (which are read with greater support from semantics), making synonym judgments, and producing exemplars in semantic fluency tasks (Nation & Snowling, 1998a). To further test the hypothesis that poor comprehenders have difficulties with fluency of semantic access, this study examines whether they show a slower time course of access to and selection of homonym meanings when homonyms are presented in isolation, without the support of surrounding context.

There is also evidence that poor comprehenders are poor at integrating word meanings in context to form coherent sentence representations, consistent with findings that they show weak inferencing skills (Cain & Oakhill, 1999; Cain, Oakhill & Elbro, 2003). Nation and Snowling (1998b) compared the performance of poor comprehenders and decoding-matched controls on a task in which printed words were primed by spoken sentences. Both groups showed faster naming responses for target words preceded by related sentences compared to words in isolation, but the benefit of context was smaller for poor comprehenders. Whether the reduced facilitation reported in this study arose from less efficient integration of words at the sentence level, slower semantic access at the word level or a failure to use predictive strategies remains unclear.

The paradigm used by Nation and Snowling (1998b) required children to read aloud words and to make explicit use of context. Counter to their findings, recent eye tracking studies which measure early and implicit sensitivity to context, have suggested that poor comprehenders may be as sensitive to sentence context as controls matched on decoding in both written (van der Schoot et al., 2009) and spoken (Nation, Marshall & Altmann, 2003) language. It follows that the difficulties which have been reported at the sentence level may be due to a difficulty at a later stage of processing such as with maintaining relevant mental representations in memory over time without interference from irrelevant information.

Consistent with this idea, another line of research suggests that poor comprehenders can access relevant information and show sensitivity to context but have difficulties inhibiting irrelevant semantic information (Cain, 2006; Gernsbacher & Faust, 1991; Gernsbacher, Varner & Faust, 1990; Nation et al., 2003; Pimperton & Nation, 2010). Gernsbacher et al. (1990) used a meaning judgement task where adult participants read sentences and then decided whether a target word was related to the sentence. The critical sentences ended with homonyms and were followed by target words related to the sentence-incongruous meaning (He dug with a spade - ACE). This condition was compared against a non-ambiguous control condition (He dug with a shovel - ACE). When target words were presented immediately after the sentence, all participants responded more slowly to probes following ambiguous than unambiguous words. However, when probes were delayed by 850ms, this pattern was obtained only for less-skilled comprehenders. Gernsbacher et al (1990) concluded that “less skilled comprehenders have less rapid (and therefore less efficient) suppression mechanisms” (p. 440). Gernsbacher and Faust (1991) found that skilled and less-skilled comprehenders were equally effective at deciding that the probe word matched the sentence meaning (He dealt the spade ACE). They argued that group differences were attributable to “suppression (of inappropriate or irrelevant information), not enhancement (of appropriate or relevant) information" (Gernsbacher, 1997, p. 178). Using Gernbacher's experimental design, Barnes, Faulkner, Wilkinson and Dennis (2004) replicated these findings comparing 12-year-old poor comprehenders with a history of early hydrocephalus and controls matched on word reading. However, group differences in general cognitive ability were not controlled leaving open the possibility that could provide an explanation for their finding that poor comprehenders were less successful at inhibiting inappropriate meanings of ambiguous words, despite showing intact contextual facilitation.

An alternative explanation of the findings of Gernsbacher et al' (1990) results is in terms of enhancement of relevant information rather than inhibition of irrelevant information. According to McNamara's (1997) 'knowledge-based' account of lexical ambiguity resolution, activation of prior knowledge plays a pivotal role in the formation of a coherent mental representation of text or discourse, so that weak inhibition can be construed as the consequence of inefficient access to relevant semantic knowledge. Thus, McNamara (1997; McNamara & McDaniel, 2004) proposed a computational model that relies solely on competition for facilitation between related units of information rather than using negative links between alternative representations of word meaning. This model demonstrated that the number of activated associations to the relevant meaning of a sentence-final homonym predicted the rate of loss of activation for the irrelevant meaning. The model assumes that skilled comprehenders activate more relevant knowledge, leading to a rapid deactivation of irrelevant meanings. In contrast, poor comprehenders activate less relevant knowledge. Although this may be sufficient to allow the relevant meaning to reach the threshold required to understand the sentence, it is not sufficient to deactivate the irrelevant meaning. In this way, reduced access to relevant knowledge can interfere with the formation of sentence-level representations.

Using cross-modal semantic priming we examined three candidate causes of comprehension difficulty in poor comprehenders: (1) a difficulty in accessing meaning at the word-level, (2) intact access to word meaning but a lack of sensitivity to sentence context, and (3) intact access to word meaning and sensitivity to context but a difficulty with the inhibition of context-inappropriate information. In Experiment 1, participants listened to homonym primes or unrelated primes; in Experiment 2 participants listened to subordinately-biased sentence primes ending in homonyms or control sentence primes. In each experiment participants then named picture targets depicting dominant and subordinate associates of the homonyms[1]. An ISI of 250ms was used to measure priming at an early point in processing (Barnes et al., 2004; Simpson & Foster, 1986) and an ISI of 1000ms was used to measure a later point in processing (Barnes et al., 2004; Booth, Harasaki & Burman, 2006). We investigated how the same children access and select homonym meanings when sentence context is and is not available, allowing us to consider the influence of word-level semantic processing difficulties on sentence-level processing. Poor comprehenders were compared to chronological-age (CA) controls to ensure any group differences in semantic priming could not be attributed to differences in reading accuracy, phonological decoding, age or nonverbal ability. Vocabulary-age (VA) controls were also included to ensure group differences were not simply due to reduced receptive vocabulary knowledge.

The age range of 8-11 years was selected since approximately 7.5 – 10% of children at this age may be categorised as poor comprehenders (Nation & Snowling, 1997; Stothard & Hulme, 1995). A previous study with 50 TD children aged 8-11 years used the same materials and methodology as the present study and did not find any significant correlations between priming effects and age, suggesting there are minimal developmental changes in this age range (Henderson, unpublished PhD thesis): dominant and subordinate priming effects were obtained at 250ms ISI but only dominant priming was evident at 1000ms ISI. When listening to subordinate-biased sentences vs. control sentences, children showed significantly faster

[1] One problem for "multiple-access" views of word recognition is the "backward priming effect". On this view, priming effects observed for multiple meanings at short ISIs may emerge because participants, upon encountering the target stimulus, develop a backwards inference to the preceding prime. It has been argued that, unlike the lexical decision task, the naming task is not as susceptible to backward priming effects. Seidenberg, Waters, Sanders & Langer (1984) measured both naming and lexical decision times for the second words of asymmetrically related word pairs, such as "stick – lip" which were highly related only in the backward direction (SOA=500ms). Only lexical decision revealed backward priming effects. Hence, the naming task was used here in an effort to reduce the influence of backward priming.

responses when naming subordinate and dominant (inappropriately related) picture targets at 250ms ISI; only subordinate priming was found at 1000ms ISI.

Experiment 1

Experiment 1 examined the time course of access to homonym meanings when homonyms were presented in isolation. A pre-test confirmed that children were familiar with both meanings of each homonym. It was hypothesised that both groups of typical readers (CA- and VA-controls) would show priming for dominant and subordinate meanings of homonyms at 250ms ISI but only dominant priming at 1000ms ISI (Henderson et al., 2011; Simpson & Burgess, 1985; Simpson & Foster, 1986). If poor comprehenders have difficulties in accessing word meanings, it was predicted they would show reduced priming at the short ISI, particularly for subordinate meanings. If this reduced priming effect is purely due to weaker vocabulary knowledge then poor comprehenders should differ only from CA controls. However, if poor comprehenders also differ to VA controls, despite being matched on receptive vocabulary knowledge and familiarity with the stimulus set, then this suggests a difficulty in the on-line fluent retrieval of low frequency word-meanings. Alternatively, if poor comprehenders have difficulty inhibiting one meaning whilst selecting another, then this should lead to intact priming at the short ISI but sustained priming for both dominant and subordinate meanings at the long ISI.

Method

Participants

Table 1 shows the assessment profiles of the participants. Seventeen poor comprehenders were selected using the following criteria: (i) single-word reading (Word Reading, BAS-II, Elliot et al., 1996) and text reading accuracy (NARA-II, Neale, 1997) above a standard score of 90, (ii) reading comprehension on the NARA-II at a standard score of 89 or below, and (iii) a 1 SD discrepancy (15 standard points) between reading comprehension and single-word reading (n=15) or if the discrepancy was between 10–14 standard points then there had to be a 1SD discrepancy between reading comprehension and text reading accuracy (n=2).

The poor comprehenders were pairwise matched to 17 TD CA controls from the same classrooms for age, single-word reading, nonword decoding (Graded Nonword Reading Test; Snowling et al., 1996), text reading accuracy, the number of stories read on the NARA-II, and nonverbal ability (Matrices, BAS-II; Elliot et al., 1996). The poor comprehenders performed significantly worse on receptive vocabulary (BPVS-II; Dunn et al., 1997) than CA controls. The poor comprehenders were significantly older than the group of 17 TD VA controls but were closely matched on receptive vocabulary. The groups did not significantly differ on a verbal working memory task (WMTB-C Listening Recall; Pickering & Gathercole, 2001).

Materials

Through pre-testing with 27 children (7–10 years), homonyms were selected for the experiments if (a) an associate was provided on a word association task that could be depicted as a picture, (b) a dominant meaning was produced over subordinate by at least 70% of children, and (c) a subordinate meaning was produced over dominant at most 30% of the time and at least 5% of the time. The final stimulus set comprised 22 homonym prime – dominant target pairs, 22 homonym prime – subordinate target pairs, 22 unrelated prime – dominant target pairs, and 22 unrelated prime – subordinate target pairs. The stimuli can be made available by contacting the authors.

Black and white line drawings (with at least 80% naming agreement in the pre-testing) were chosen to represent dominant and subordinate associates of each homonym; 27 from Snodgrass and Vanderwaart's (1980) database and 17 from www.clipart.com. Picture names for dominant and subordinate conditions were matched for length and frequency (MRC Psycholinguistic Database, Version, 2.00, Wilson, 1988). The majority of the prime-target pairs were functionally related (3/22 were categorically related for the dominant condition and 2/22 were categorically related for the subordinate condition).

Unrelated unambiguous primes were matched to the homonym primes for phonological and orthographic neighbourhood size and frequency using the Children's Printed Word Database (www.essex.ac.uk/psychology/cpwd), and for concreteness, familiarity, imageability and age of acquisition using the MRC Psycholinguistic Database (Version, 2.00, Wilson, 1988). Table 2 shows example stimuli.

Design

Participants were presented with all 88 trials for each ISI. ISI conditions were administered on different days in a counterbalanced order with at least one week between testing. The trials were divided into two blocks separated by a 10 minute break. Pictures and homonyms were only encountered once in each block. The relatedness proportion was 50%. Related or unrelated conditions did not occur more than three times consecutively.

Procedure

Participants were instructed to listen to each word and name the picture as quickly and carefully as possible (Figure 1). A microphone connected to a voice key measured naming RT from the onset of the picture. The experimenter recorded item accuracy.

Meaning familiarity post-test

To measure participants' familiarity with the homonyms used in the experiment, a post-test was administered using E-prime (Schneider Eschman, & Zuccolotto, 2002). Children heard each homonym three times; once with a dominant picture, once with a subordinate picture, and once with an unrelated picture. Children responded yes/no if they thought the word-picture pair was related or not. Filler items ensured that 50% of the item pairs were related. Two lists with opposite orders were counterbalanced across participants where the same word did not appear in succession. The number of unfamiliar dominant and subordinate meanings and number of incorrect responses to unrelated items were very low. There were no group differences for the number of incorrect responses to unrelated (poor comprehenders 0.18/22, SD=0.39; CA controls 0.12, SD=0.33; VA controls 0) or dominant items (poor comprehenders 0.41, SD=0.62; CA controls 0.12, SD=0.33; VA controls 0.12, SD=0.33). The poor comprehenders showed significantly more incorrect responses to subordinate items than the CA controls ($p<.05$) but not the VA controls ($p>.05$) (poor comprehenders 1.41, SD=1.28; CA controls 0.41, SD=0.62; VA controls 1.0, SD=1.37).

Results

Mean picture naming RTs and naming errors for correct responses are shown in Table 3. Naming errors were low and were not analysed further. RTs were removed from the data set on a participant-by-participant basis if (1) the participant was unfamiliar with the homonym meaning in the post-test, (2) the microphone had falsely recorded an item, and (3) pictures were named incorrectly. Extreme RTs were not removed (Ulrich & Miller, 1994). For the 250ms ISI, significantly more items were removed for the poor comprehenders (mean 8.56%, SD=6.37%) than the CA controls (mean 4.76%, SD=3.01%) ($p<.05$) but the poor comprehenders and VA controls (mean 7.47%, SD=4.21%) did not significantly differ ($p>.05$), $F(2, 50)=3.17$, $p<.05$. For the 1000ms ISI, marginally more items were removed for poor comprehenders (mean 9.06%, SD=6.79%) than CA controls (mean 5.41%, SD=3.22%) ($p=.06$) but there was no difference between poor comprehenders and VA controls (mean 6.35%, SD=4.31%) ($p>.05$), $F(2, 50) = 2.30$, $p = .06$.

The RT data show that poor comprehenders were slower in all conditions compared with CA but not VA controls. All groups were faster to name dominant targets if they were preceded by related homonyms than unrelated primes at both 250 and 1000ms ISIs. At 250ms ISI the control groups were also faster to name subordinate targets if they were related to homonym primes but the poor comprehenders did not show subordinate priming. To confirm this pattern, the data were entered into a mixed-design ANOVA for each ISI separately[2]. The within-subjects variables were Association (dominant, subordinate) and Relatedness (related, unrelated), and the between-subjects variable was Group (poor comprehenders, CA controls, VA controls). Picture naming RT (by participants) was the dependent variable.

250ms ISI

Poor comprehenders were slower to name pictures than CA controls ($t(32)=2.78, p<.01$) but not VA controls ($t(32)=1.04$, $p>.05$) (Group, $F(2, 48)=3.95$, $p<.05$,

[2] We first carried out a 4-way mixed-design ANOVA including ISI as an additional within-subject factor. There was a significant ISI x Association x Relatedness interaction, $F(1, 48) = 10.83$, $p < .01$, $\eta_p^2 = .18$, which justifies our decision to separate the analysis by ISI condition and test specific hypotheses about each ISI in turn. The ISI x Association x Relatedness x Group interaction was not significant, $F(2, 48) = 0.17$, $p > .05$, $\eta_p^2 = .01$.

η_p^2=.14). Pictures were named faster if they were preceded by homonym than unrelated primes (Relatedness, $F(1, 48)=26.58$, $p<.001$, η_p^2=.36) and if the pictures were dominant than subordinate associates of the homonyms (Association, $F(1, 48)=11.50$, $p<.001$, η_p^2=.19). The Association × Relatedness × Group interaction did not reach significance, likely due to large variability (see Table 3) particularly for the VA controls and poor comprehenders ($F(2, 48)=1.80$, $p>.05$, η_p^2=.07). However, the Association × Relatedness × Group interaction was significant when the VA controls were omitted from the analysis ($F(1, 32)=4.71$, $p<.05$, η_p^2=.13) justifying the examination of Group influences on priming effects using planned contrasts. All groups showed dominant priming (poor comprehenders mean difference 135ms; 95% CI 39–232ms, $t(16)=-2.99$, $p<.01$; CA controls mean difference 66ms; 95% CI 21–112ms, $t(16)=-3.09$, $p<.01$; VA controls mean difference 129ms; 95% CI 58-198ms, $t(16)=3.91$, $p<.01$) but only the control groups showed subordinate priming (poor comprehenders mean difference 33ms; 95% CI -50ms – 117ms), $t(16)<1$; CA controls mean difference 69ms; 95% CI 9 – 129ms, $t(16)=-2.44$, $p<.05$; VA controls mean difference 71ms 95% CI 0.68-143ms, $t(16)=2.10$, $p<.05$).

1000ms ISI

At the long ISI the main effects of Relatedness and Association were again significant (Relatedness, $F(1,48)=4.42$, $p<.05$, η_p^2=.08; Association, $F(1,48)=32.09$, $p<.001$, η_p^2=.40). There was a marginal effect of Group, $F(2,48)=4.21$, $p<.05$, η_p^2=.12; the poor comprehenders were slower than the CA controls ($t(32)=2.05$,$p<.05$) but not the VA controls ($t(32)<1$). All groups showed significant priming for dominant targets (mean difference 102ms; 95% CI 69–136ms) but the subordinate priming effect was in the opposite direction with unrelated targets named faster than related targets (mean difference -53ms; 95% CI -80–25ms) (Relatedness × Association interaction, $F(1,48)=63.16$, $p<.001$, η_p^2=.57). No other interactions were significant.

To reduce the influence of naming speed on the size of the priming effects (Chapman et al., 1994), ratio scores are presented instead of raw differences in Figure 2 to express the priming scores as a proportion of naming speed (Burke, White & Diaz, 1987; Howard, Shaw & Heisey, 1986; Tompkins, Baumgaertner, Lehman, & Fossett, 1997). The pattern of priming remains the same when group differences in naming speed are controlled. It is therefore unlikely that naming speed differences alone account for the results, particularly since the group differences in priming effects were confined to the short ISI.

Discussion

For the 250ms ISI, both control groups showed significant dominant and subordinate priming; for the 1000ms ISI they only showed dominant priming. This general pattern of priming is consistent with the findings of previous semantic priming studies with homonyms (Henderson et al., 2011; Simpson & Burgess, 1985; Simpson & Foster, 1986). Whilst the younger VA controls showed larger dominant priming than subordinate priming at the short ISI (as in Simpson & Foster, 1986), the size of the dominant and subordinate priming effects was similar for the CA controls. The relative size of priming effects for words differing in meaning frequency is likely to be strongly influenced by the ISI and be characterised by large individual and developmental differences. It is possible that the older CA controls may have shown a stronger frequency effect at shorter ISIs than used in this study (Henderson, unpublished PhD thesis).

Subordinate picture targets were named significantly more slowly when preceded by a homonym prime than an unrelated prime at the 1000ms ISI. This could suggest that the subordinate meanings of the homonyms were inhibited on presentation of the homonym prime which hindered children's ability to retrieve the picture name. Consistent with this, experiments that have incorporated a neutral baseline (in addition to related and unrelated conditions; Simpson & Foster, 1986; Simpson & Burgess, 1985) have reported that subordinate targets are responded to significantly slower when they are preceded by related homonyms than neutral primes, suggesting they are inhibited after their initial activation (Neely, 1977). While it is important to emphasise that strong claims about the presence of 'inhibition' of the unselected meaning cannot be made solely on the basis of the present data, using the same materials and ISIs, we have also shown that TD children name subordinate targets significantly more slowly when they are preceded by related-homonym than neutral (nonword) primes (Henderson, unpublished PhD thesis).

Despite showing a large dominant priming effect, the poor comprehenders did not show subordinate priming at the short ISI in contrast to CA and VA controls. This finding is consistent with the hypothesis that poor comprehenders have difficulty in accessing the subordinate meanings of homonyms despite being familiar with them on a receptive vocabulary task. The receptive vocabulary task involved simple 'yes-no' judgements about word-picture pairs; whilst this is a good test of vocabulary breadth, it may underestimate depth - the vocabulary dimension in which poor comprehenders differ most from TD children. The finding that poor comprehenders' showed reduced subordinate priming at the 250ms ISI is consistent with this idea and emphasises the fact that they have impaired semantic knowledge for low-frequency words.

Contrary to the hypothesis of an inhibition deficit there was no evidence that poor comprehenders fail to select a single meaning of homonyms and reject other meanings (at least when the meanings to be inhibited are subordinate in frequency) since only the dominant meaning was primed at the long ISI. It remains possible that poor comprehenders may have shown smaller inhibition effects than controls had a neutral baseline condition been included; however, the strong form of the inhibition deficit hypothesis was not supported here.

Experiment 2

Experiment 2 investigated the time course of semantic access to homonym meanings in sentence context. We examined the extent to which poor comprehenders can integrate semantic information, select contextually appropriate information and inhibit contextually inappropriate information. The same children listened to subordinately biased sentences ending in homonyms or control sentences. Following an ISI of 250ms or 1000ms they named target pictures depicting the subordinate meaning of the sentence-final homonym (appropriately related) or target pictures depicting the dominant meaning of the homonym (inappropriately related) (Table 4). Critical sentences in each condition were subordinately biased on the assumption that this necessitates the inhibition of dominant (inappropriate) meanings, which have a higher relative frequency.

At the 250ms ISI, we predicted that both control groups would show ‘appropriate priming’ for picture targets of subordinate meanings when they were preceded by subordinate-biased than control sentences and ‘inappropriate priming’ for dominant picture targets when they were preceded by subordinate-biased than control sentences. At this ISI both dominant and subordinate meanings should be automatically accessed (Barnes et al., 2004; Henderson et al., 2011). At the 1000ms ISI, we predicted that controls would only show appropriate priming since at this point the context-inappropriate (dominant) meaning should be inhibited.

At the 250ms ISI, if poor comprehenders have difficulties with integrating semantic information when hearing sentences in order to activate context appropriate information, they should show reduced appropriate priming compared to controls. We also predicted that poor comprehenders should show intact inappropriate priming at this ISI, since they should have little difficulty accessing the dominant (inappropriate) meanings. Based on the impaired semantic integration hypothesis, at the 1000ms ISI, poor comprehenders should continue to show reduced appropriate priming. Alternatively, if their ability to integrate semantic information in sentence context is intact but they have difficulties inhibiting irrelevant information, then they should show appropriate priming accompanied by inappropriate priming in contrast to controls. If group differences in priming are due to poor comprehenders’ weaker vocabulary knowledge then they should differ only from CA and not VA controls.

Method

Design and Materials

The materials were designed to test appropriate and inappropriate priming, using a within-subjects design. The 22 homonyms and 44 pictures from Experiment 1 were used. For each homonym, four sentences were constructed (hence children responded to 88 experimental sentences). Each sentence contained four or five words. Half of the sentences were used in the appropriate condition, half were used in the inappropriate condition.

To measure appropriate priming all sentences ended with homonyms. “Control” sentences had neutral context and granted either meaning acceptable; “Biased” sentences rendered the subordinate meaning appropriate by altering the verb. Control and biased sentences were followed by congruent (subordinate) pictures. In a preparatory experiment, we ensured that the subordinate picture targets were not primed by the biased versus neutral verbs when they were presented as single-word primes. Hence, any priming from the biased sentences can be attributed to the integration of the verb with the homonym.

To measure inappropriate priming, the verbs were identical in both conditions but the sentence pairs differed in their final words. “Control” sentences ended with unambiguous synonyms that were unrelated to the dominant target whereas “Inappropriate” sentences were subordinately biased and ended with homonyms that were inappropriately related to the dominant target. Unambiguous and ambiguous word endings for the inappropriate condition were matched for length, frequency, imageability and age of acquisition. Sentences were recorded by the same speaker as for the single-word task.

Sentences were divided into blocks so that a homonym only occurred once in each. Blocks were separated by 5 minute breaks and counterbalanced for order. No condition occurred more than three times consecutively. Six practice items were administered.

Procedure

The procedure was the same as for Experiment 1 but children were instructed to listen to each sentence. ISI conditions were administered in separate sessions that were counterbalanced across participants, with at least a week between each session to reduce the influence of item repetition. The sentence task (Experiment 2) was also administered at least one week after the single-word task (Experiment 1).

Results

The mean picture naming RTs for correct responses and naming errors are shown in Table 5. Microphone errors, naming errors and unfamiliar items on the post-test were not included in the analysis of naming RT. For the 250ms ISI, more items were removed for poor comprehenders (mean 11.76%, SD=8.57%) than CA controls (mean 5.95%, SD=3.94%) ($p<.05$) but there was no difference between the poor comprehenders and VA controls (mean 9.22%, SD=6.92%) ($p>.05$), $F(2, 50)=3.17$, $p<.05$. For the 1000ms ISI, more items were removed for poor comprehenders (mean 11.90%, SD=8.99%) than CA controls (mean 6.36%, SD=4.06%) ($p<.05$) but there was no difference between poor comprehenders and VA controls (mean7.48%, SD=6.99%) ($p>.05$), $F(2,50)=2.99$, $p=.06$.

At the 250ms ISI, all groups were faster to name subordinate picture targets if they were preceded by subordinate-biased sentences than control sentences ('appropriate priming'). The VA controls and poor comprehenders were also faster to name dominant picture targets if they were preceded by subordinate-biased sentences than control sentences ('inappropriate priming'); the CA controls showed a numerically smaller inappropriate priming effect. At the 1000ms ISI, the control groups only showed appropriate whereas the poor comprehenders only showed inappropriate priming. The picture naming RT data were entered into a mixed-design ANOVA for each ISI separately[3]. The within-subjects variables were Sentence Context (subordinate-biased, control) and Picture Congruence (Appropriate, Inappropriate). The between-subjects variable was Group (poor comprehenders, CA controls, VA controls).

250ms ISI

There was a trend for the poor comprehenders to name the pictures slower than CA controls ($p<.05$) but not VA controls ($p>.05$) (Group, $F(2, 48)=2.52$, $p=.09$, $\eta_p^2=.10$). Children were faster to name picture targets when they were preceded by biased than control sentences (Sentence Context, $F(1,48)=43.24$, $p<.001$, $\eta_p^2=.47$). Although there were no significant interactions, the CA controls showed a numerically small (non-significant)

[3] We first carried out a 4-way mixed-design ANOVA including ISI as an additional within-subject factor. There was a significant main effect of ISI, $F(1,48)=10.16$, $p<.01$, $\eta_p^2=.18$, and significant interactions between Context x Appropriateness, $F(1,48)=4.19$, $p<.05$, $\eta_p^2=.08$, Context x ISI, $F(1,48)=17.60$, $p<.001$, $\eta_p^2=.27$, Context x ISI x Group, $F(2,48)=3.37$, $p<.05$, $\eta_p^2=.12$, and Context x Appropriateness x Group, $F(2, 48)=2.91$, $p<.05$, $\eta_p^2=.11$, which justifies separate ANOVAs to test specific hypotheses about each ISI.

inappropriate priming effect ($t(16)<1$) in contrast to the VA controls ($p<.01$) and poor comprehenders ($p<.05$). There were no other significant main effects or interactions.

1000ms ISI

There was a trend for poor comprehenders to name the pictures slower than the CA controls ($p<.05$) but not the VA controls ($p>.05$) (Group, $F(2, 48)=2.99$, $p=.06$, $\eta_p^2=.11$). There were significant interactions between Picture Congruence×Group ($F(2, 48)=3.25$, $p<.05$, $\eta_p^2=.12$) and Sentence Context×Picture Congruence ($F(1,48)=6.16$, $p<.05$, $\eta_p^2=.11$) and a marginal Sentence Context×Group interaction ($F(2,48)=3.01$, $p=.06$, $\eta_p^2=.11$). These interactions were qualified by a Sentence Context×Picture Congruence×Group interaction ($F(2, 48)=4.91$, $p<.05$, $\eta_p^2=.17$). Controls showed significant appropriate priming (CA mean difference 89ms, SD=149ms, 95% CI 11–166ms, $t(16)=2.45$,$p<.05$; VA mean difference 57ms, SD=91ms, CI 10-104ms, $t(16)=2.60$,$p<.05$) but no inappropriate priming (CA mean difference -67ms, SD=187ms, 95% CI -163–29ms, $t(16)=1.47$, $p>.05$, VA mean difference -89ms, SD=126ms, 95% CI -154ms–24ms, $t(16)=2.92$, $p<.01$). In contrast, poor comprehenders did not show significant appropriate priming (mean difference 29ms, SD=178ms, 95% CI -62ms–121ms, $t(16)<1$) but showed significant inappropriate priming (mean difference 92ms, SD=129ms, 95% CI 25–158ms, $t(16)=2.94$, $p<.01$). There were no other significant main effects or interactions. The pattern of results for each condition and ISI remains consistent when expressed as prime ratio scores (Figure 3).

Discussion

At the 250ms ISI, controls were faster to name subordinate picture targets when they were preceded by subordinately-biased sentences than control (neutral) sentences (‘appropriate priming’) consistent with our hypothesis. Only the younger VA controls were faster to name dominant picture targets when they were preceded by subordinately-biased sentences than control sentences (‘inappropriate priming’). The absence of inappropriate priming for the CA controls at 250ms ISI is somewhat inconsistent with previous studies (Barnes et al., 2004; Gernsbacher et al., 1990; Swinney, 1979). However, direct comparisons are problematic since studies have differed in the samples, tasks (e.g., meaning judgement, lexical decision) and ISI/SOA conditions used. The finding that the younger VA controls showed early inappropriate priming is suggestive of developmental changes in the time course of the priming effects with an earlier onset of priming with increasing school-age. Had a shorter ISI been included here is possible that the CA controls would also have shown inappropriate priming at an earlier point in processing than measured here. Using the same methodology and stimuli, Henderson et al (2011) also reported that TD children (mean 11.5 years) did not show inappropriate priming at the same ISI.

Counter to the hypothesis that poor comprehenders have difficulty integrating semantic information in sentence context they showed appropriate priming for subordinate targets at the 250ms ISI, similar to controls, even though they had not shown it at the same ISI in the single-word condition. Poor comprehenders also showed inappropriate priming at the 250ms ISI. Since this pattern of inappropriate priming was more akin to that demonstrated by the younger VA controls it suggests that poor comprehenders show a developmental lag in the speed with which contextually inappropriate meanings reduce in activation.

At the 1000ms ISI, poor comprehenders no longer showed appropriate priming but instead showed significant inappropriate priming in stark contrast to both control groups. Although this finding clearly suggests that poor comprehenders have difficulties inhibiting inappropriate meanings, the pattern of results is inconsistent with the inhibition deficit hypothesis which predicts both inappropriate and appropriate priming. Gernsbacher and colleagues (Gernsbacher et al., 1990; Gernsbacher & Faust, 1991) reported that less-skilled comprehenders showed intact ‘context facilitation’ when responding to context relevant targets, but impaired ‘suppression’ when rejecting context irrelevant targets (see also Barnes et al., 2004). When viewed together with the lack of subordinate priming for poor comprehenders in the single-word experiment, the heightened inappropriate priming in poor comprehenders is likely to be a consequence of a deficit within the semantic system. More specifically, a difficulty in accessing subordinate meanings at the word-level could account for the persistence of inappropriate (dominant) meanings and the reduction in appropriate (subordinate) meanings over time.

General Discussion

Previous studies have found that poor comprehenders show word-level semantic deficits characterised by inefficient retrieval of semantic knowledge, particularly for low - frequency and less imageable words (Nation & Snowling, 1998a, 1999; Nation et al., 2001). Other research suggests that poor comprehenders may have decreased sensitivity to sentence context (Nation & Snowling, 1998b) or specific problems with the inhibition of irrelevant semantic information (Barnes et al., 2004; Cain, 2006; Gernsbacher et al., 1990; Gernsbacher & Faust, 1991). We investigated semantic access and selection of homonym meanings at the word level (where meaning selection is shaped by meaning frequency) and at the sentence level (where meaning selection is influenced by the ability to integrate semantic information from sentences and inhibit irrelevant meanings). The pattern of data obtained is clear and provides new information on the nature of the semantic deficit in poor comprehenders.

Experiment 1 explored whether poor comprehenders are able to access multiple meanings of homonyms early in the time course of processing and select a single meaning based on meaning frequency. The results suggest a difficulty with early semantic access; the poor comprehenders did not show subordinate priming at 250ms despite being familiar with subordinate meanings on a control task where they were required to explicitly access the meanings. Counter to the inhibition deficit hypothesis, poor comprehenders did not have difficulties inhibiting redundant (subordinate) information; they showed selective priming for dominant meanings at the long ISI.

These results build on previous evidence of poor vocabulary knowledge in poor comprehenders and suggest, in line with the lexical quality hypothesis (LQH; Perfetti, 2007) that their semantic network is characterised by poorly coded semantic representations, particularly for less frequent meanings, despite adequate decoding and phonological-level skills (Nation & Snowling, 1998a; Nation & Snowling, 1999). Although poor comprehenders and controls were familiar with the homonyms, they differed in the ease with which their subordinate meanings were retrieved; according to the LQH , this lack of flexibility has consequences for comprehension. To explore this further, future studies could use a masked prime condition to measure automatic priming effects at an even earlier point in processing to provide further evidence for the view that poor comprehenders' deficit lies in the automatic access to meaning.

Consistent with our findings, Nation and Snowling (1999) suggested that the semantic deficit in poor comprehenders reflects weaker activation of abstract semantic associations. They reported that the poor comprehenders showed semantic priming for functionally related prime-target pairs and for categorically related items that were highly associated but they did not show priming for categorically related items that were not commonly associated. In the present experiments, the majority of prime-target pairs in both the dominant and subordinate conditions were functionally related. Therefore, our results suggest that poor comprehenders may not always show priming for functionally related pairs, that is, when these relationships involve subordinate meanings of homonyms.

The finding that subordinate priming was absent at 250ms in poor comprehenders is similar to the results of Frenck-Mestre and Prince (1997, Experiment 1b) which utilised a single-word semantic priming task with lexical decision. They found that advanced French learners of English exhibited significant priming for both dominant and subordinate targets when they were preceded by homonym primes compared to unrelated primes at 100 and 300ms SOAs, whereas less proficient French learners of English showed priming only for dominant meanings at both SOAs. This lack of priming for subordinate meanings occurred despite an off-line recognition task that showed that the less proficient group was familiar with the subordinate meanings. This concurs with our view that impoverished knowledge of later acquired subordinate meanings and/or an impaired ability to retrieve them may underpin the lack of early subordinate priming in poor comprehenders.

Rodd, Gaskell, and Marslen-Wilson (2004) implemented a distributed model in which semantic representations of ambiguous words were modelled as stable states within semantic space. In this network, the initial pattern of activation generated when encountering a homonym is a "blend" between the word's different meanings; recurrent connections "clean up" this pattern of activation by continuously modifying it until it becomes a stable *attractor state* that corresponds to a single meaning. The frequencies of the meanings and the initial activation of the network determine which of the attractors is settled into. For poor comprehenders, if dominant meanings have even higher relative meaning frequencies than subordinate meanings (compared to TD controls) then the initial blend of activation on encountering a homonym will be more heavily weighted by the dominant meanings and the likelihood of priming for subordinate meanings will be reduced.

Despite showing difficulties in accessing subordinate meanings, poor comprehenders were as sensitive to subordinately biased sentence contexts as controls at the 250ms ISI (see also Nation et al., 2003; van der Schoot et al., 2009). At first glance this seems surprising, since the poor comprehenders had difficulties accessing subordinate meanings in the absence of supporting context. One possibility, compatible with the LQH, is that weaker representations are more 'context-bound' (Perfetti, 2007) and therefore poor comprehenders may rely *more* on sentence context than controls when accessing subordinate information. It follows that the low quality semantic representations of poor comprehenders may impede comprehension by increasing the attentional demands of word identification and deflecting attention away from the goal of reading (i.e., to comprehend).

Consistent with this view, poor comprehenders were not able to maintain their sensitivity to subordinate sentence context at the 1000ms ISI, in contrast to the control groups. Furthermore, they had clear difficulties inhibiting contextually inappropriate information (Barnes et al., 2004; Gernsbacher & Faust, 1991; Gernsbacher et al., 1990) and hence showed priming for inappropriate meanings that was not present in the controls. We propose that the persistence of inappropriate priming is a consequence of the deficit in accessing subordinate meanings observed in single-word context. Although the poor comprehenders were able to activate appropriate (subordinate) meanings immediately after hearing the subordinate sentence, these meanings may not have reached a sufficiently high level of activation relative to the level of inappropriate (dominant) meanings to render the inappropriate (dominant) meanings unavailable. This explains why the dominant (inappropriate) meaning persisted in activation at the 1000ms ISI whereas the subordinate (appropriate) meaning lost activation. This view is partly compatible with McNamara's (1997) hypothesis that the level of activation of irrelevant meanings is determined by the level of activation of the relevant meanings. However, we are not arguing here that there is a "fixed cap" of activation that must be distributed across competing representations; rather we are arguing that the crucial determinant of which representation is selected for further processing is the relative difference in activation between the two representations. For poor comprehenders who have impoverished subordinate representations, dominant meanings are likely to have an even higher relative meaning frequency than subordinate meanings. It follows that activation of the relevant (subordinate) meanings may have had to reach a significantly greater threshold to enable deactivation of the inappropriate (dominant) for poor comprehenders than controls. Hence, our results suggest that an inhibition deficit is too specific an explanation for comprehension failure in poor comprehenders because it neglects the role of semantic knowledge in influencing higher-level comprehension processes.

Taking a similar approach to the definition and recruitment of poor comprehenders to the present study, Pimperton and Nation (2010) compared poor comprehenders and decoding-matched controls on both verbal and non-verbal versions of a proactive interference task designed to assess their ability to suppress no-longer-relevant information from working memory. The poor comprehenders showed domain-specific suppression deficits, demonstrating impairments relative to the controls in the verbal (but not the nonverbal) version of the task. Together with the present findings, this suggests that difficulties with inhibition are likely to be a consequence of failing to sufficiently activate relevant information and be part of broader oral language impairment. It is also important to note that we obtained differences in priming despite the groups being well matched on verbal working memory, whereas Pimperton and Nation (2010) reported difficulties with inhibition on a working memory task. This strengthens the argument that difficulties with inhibition observed in poor comprehenders are likely to be independent of working memory skill and are more likely to be a consequence of difficulties with semantic activation.

The present findings have implications for children with reading comprehension impairment who may have weaknesses in the efficiency with which word meanings can be accessed. For such children, intervention strategies that focus on vocabulary instruction and encourage children to activate vocabulary knowledge during reading and listening are likely to be beneficial (Clarke, Snowling, Truelove & Hulme, 2010). Furthermore, our findings suggest that poor comprehenders' difficulties with accessing word meaning may be particularly pronounced in implicit on-line tasks and in naturalistic conditions (when no cues are provided to initiate activation of word meaning).

In conclusion, the present findings suggest that access to semantic representations is modulated by individual differences in the relative frequencies of different word meanings and by context. We have shown that 8-11 year-old children can access multiple meanings of homonyms early in the time course of semantic processing, before selecting a single meaning on the basis of lexical frequency and context. Poor comprehenders found it harder to access semantic information, particularly subordinate meanings. In turn, this had adverse effects on their sentence-level representations, compromising their ability to inhibit irrelevant information and maintain activation of context appropriate information. These results elucidate the semantic deficit in poor comprehenders and cast doubt on the view that a deficit in inhibition is for them a core cognitive impairment. Rather, difficulties with inhibition are more likely to be the consequence of word-level semantic difficulties.

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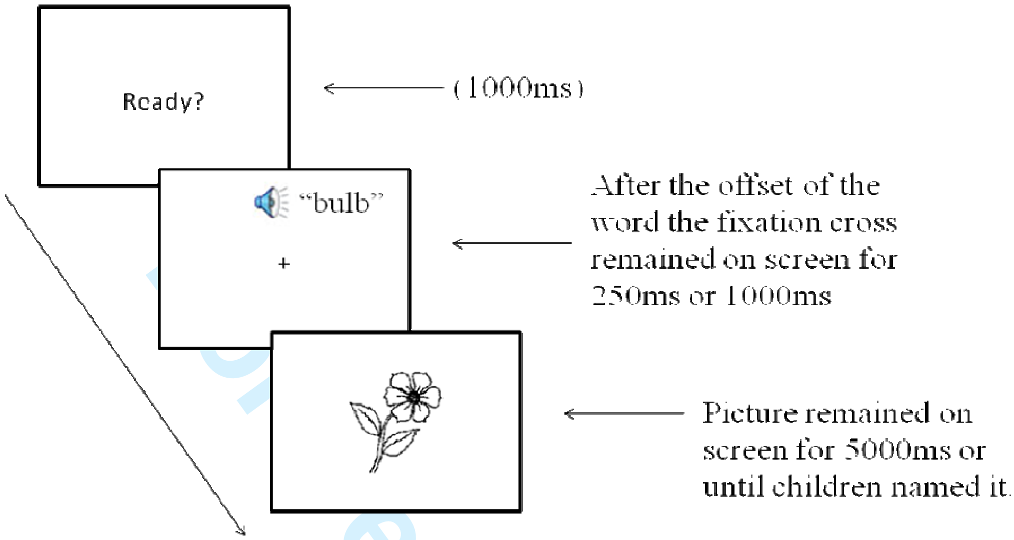

Figure 1. Example of a subordinate – related trial from Experiment 1.

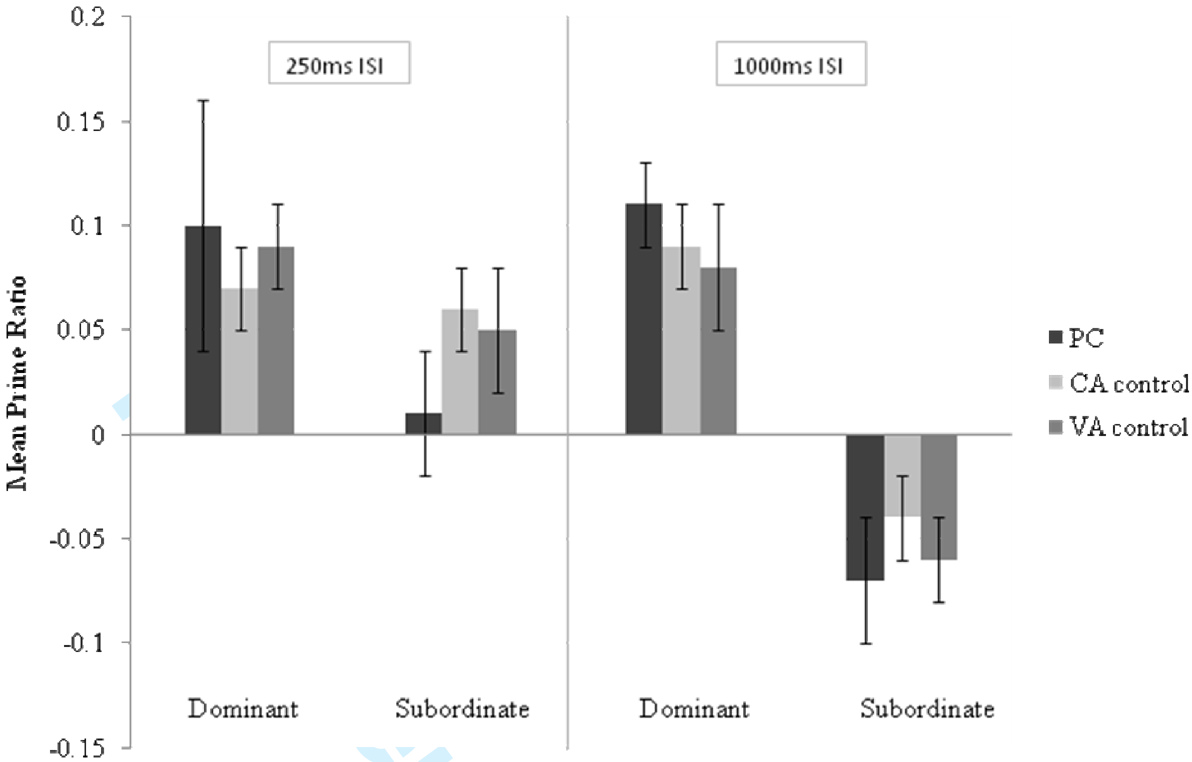

Figure 2. Mean dominant and subordinate priming ratios for 250ms and 1000ms ISIs for poor comprehenders (PC) and controls. Prime ratios were calculated by the difference between unrelated and related conditions divided by the unrelated condition (for dominant and subordinate conditions separately). Standard error bars are shown.

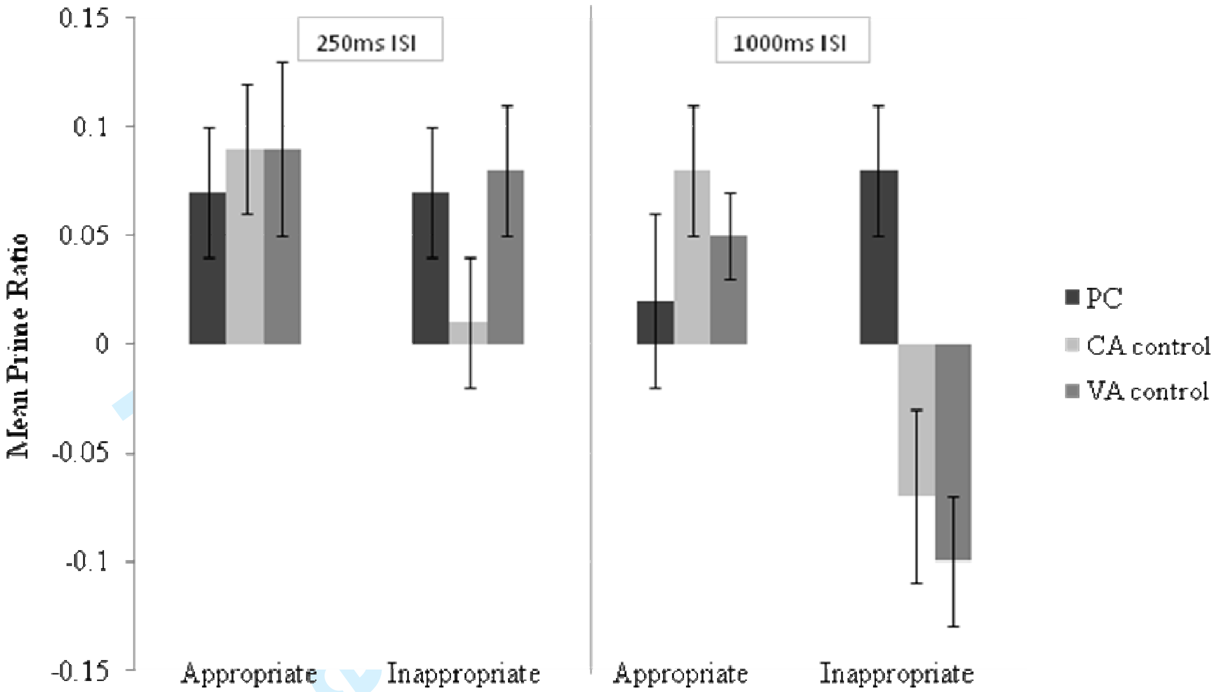

Figure 3. Mean appropriate and inappropriate priming ratios for 250ms and 1000ms ISIs for poor comprehenders (PC) and controls. Prime ratios were calculated by the difference between neutral or control and biased or inappropriate conditions divided by the neutral or control condition. Standard error bars are shown.

Table 1. Descriptive measures for the poor comprehenders, CA controls and VA controls

	Poor comprehenders (n = 17)		CA controls (n = 17)		VA controls (n = 17)		*F*
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	
Age (yrs)	10.10 (0.59)	8.92 – 11	10.06 (0.71)	9 – 11.33	9.01 (0.85)	7.66 – 10.16	12.23**,VA<PC/CA
Receptive vocab age (years)	8.79 (1.34)	6.75 – 10.83	10.52 (1.48)	8.66 – 13.66	8.85 (1.12)	7.25 – 11.58	9.45**, CA<VA/PC
Word Reading (ss)	106.06 (11.08)	86 – 124	109.25 (16.29)	90 – 145	106.94 (11.86)	87 – 129	< 1
Nonword reading (out of 25)	18.94 (4.94)	11 - 25	18.31 (4.78)	9 – 25	18.82 (3.34)	10 – 25	< 1
Text reading accuracy (ss)	101.29 (9.57)	85 – 115	105.56 (12.47)	86 – 129	103.06 (10.38)	85 – 121	< 1
Text reading fluency (ss)	103.71 (11.44)	82 – 125	110.29 (11.51)	93 – 130	106.29 (9.41)	85 – 124	1.60, *ns*
Text comprehension (ss)	84.82 (4.79)	69 – 89	101.69 (7.25)	91 – 113	100.12 (6.36)	90 – 116	37.94**PC<VA/CA
N stories read NARA-II (6 max)	5 (1.0)	3 – 6	4.94 (1.10)	3 – 6	4.53 (0.87)	3 – 6	1.14, *ns*
Nonverbal IQ (T score)	50.00 (11.31)	32 – 72	47.71 (6.34)	34 – 59	52.82 (5.73)	43 – 64	1.67, *ns*
Verbal Working Memory (ss)	95.88 (17.62)	59 – 122	99.53 (11.42)	77 – 117	95.59 (12.79)	76 – 117	0.41, *ns*

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Chapter Five

Table 2. Example stimuli for Experiment 1.

Word Prime	Dominant Picture Target	Subordinate Picture Target
Related = “bulb” Unrelated = “cake”		

Table 3. Mean picture naming RT (in ms) and mean naming errors (out of 22) for dominant and subordinate conditions and raw priming scores (in ms) for each ISI condition in Experiment 1.

	Dominant			Subordinate		
	Related	Unrelated	Priming	Related	Unrelated	Priming
250ms ISI – Naming RT						
VA Controls	960 (197)	1089 (260)	129	995 (204)	1066 (257)	71
CA Controls	824 (137)	890 (184)	66	923 (173)	992 (252)	69
PCs	1001 (199)	1137 (315)	136	1133 (239)	1166 (298)	33
250ms ISI – Naming Errors						
VA Controls	0.47 (0.62)	0.41 (0.71)	-.06	0.35 (0.49)	0.41 (0.71)	.06
CA Controls	0.18 (0.39)	0.24 (0.56)	.06	0.12 (0.33)	0.18 (0.39)	.06
PCs	0.31 (0.79)	0.50 (0.73)	.19	0.31 (0.87)	0.50 (0.97)	.19
1000ms ISI – Naming RT						
VA Controls	910 (172)	994 (156)	84	1079 (219)	1015 (185)	-64
CA Controls	795 (139)	879 (178)	84	927 (226)	884 (180)	-43
PCs	916 (179)	1057 (280)	141	1074 (241)	1022 (288)	-52
1000ms ISI – Naming Errors						
VA Controls	0.12 (0.33)	0.24 (0.44)	.12	0.12 (0.33)	0.29 (0.59)	.17
CA Controls	0 (0)	0.18 (0.39)	.18	0.24 (0.44)	0.29 (0.69)	.05
PCs	0.18 (0.39)	0.41 (0.79)	.23	0.24 (0.44)	0.41 (0.71)	.17

Note. PCs = poor comprehenders

Table 4. Example stimuli for Experiment 2

Condition	Sentence Prime	Target
Appropriate		
Subordinate-Biased	"Helen planted the bulb"	
Control	"Bill bought the bulb"	
Inappropriate		
Subordinate-Biased	"David planted the bulb"	
Control	"Ann planted the seed"	

Table 5. Mean picture naming RT (in ms) and mean naming errors (out of 22) for appropriate and inappropriate priming conditions and raw priming scores (in ms) for each ISI condition in Experiment 2.

	Appropriate			Inappropriate		
	Neutral	Biased	Priming	Control	Inappropriate	Priming
250ms ISI						
Naming RT						
VA Controls	1231 (305)	1107 (294)	124	1251 (365)	1139 (316)	112
CA Controls	1012 (317)	919 (314)	93	981 (341)	956 (325)	25
PC	1124 (250)	1032 (202)	92	1159 (290)	1053 (234)	106
Naming Errors						
VA Controls	0.06 (0.24)	0.06 (0.24)	0	0.29 (0.47)	0.41 (0.71)	-.12
CA Controls	0.06 (0.24)	0.06 (0.24)	0	0 (0)	0 (0)	0
PC	0.24 (0.56)	0.06 (0.24)	.18	0.53 (0.72)	0.41 (0.71)	.12
1000ms ISI						
Naming RT						
VA Controls	1054 (245)	996 (224)	58	1023 (264)	1112 (259)	-89
CA Controls	932 (278)	844 (187)	88	864 (198)	931 (304)	-67
PC	1092 (181)	1063 (213)	29	1075 (226)	983 (197)	92
Naming errors						
VA Controls	0 (0)	0 (0)	0 (0)	0 (0)	0.06 (0.24)	-.06
CA Controls	0.06 (0.24)	0 (0)	.06	0 (0)	0.06 (0.24)	-.06
PC	0.24 (0.44)	0.18 (0.39)	.06	0.29 (0.47)	0.18 (0.39)	.11

Note. PC = poor comprehender